ARMYWORMS (DIP: SCIARIDAE) IN WEST SCOTLAND IN 2005

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Abstract

Two-hundred and three moving columns of larvae of *Sciara militaris* Nowacki (Dip.: Sciaridae) were observed at Barcaldine, Argyll, between 19 July and 6 August 2005, the second year of their appearance at this site. The longest column measured 398 cm and the greatest number of columns present at one time was 22. Estimates of the numbers of thousands of larvae present in four columns of different sizes were about 5, 8, 16 and 26; and the highest total present at any one time was about 110,000 – 220,000 larvae. Column fronts moved at 1-2 cm/min, but larvae on the upper surface of columns moved 3-4 times faster. Columns were most numerous in the mornings. Two unbroken rings of marching larvae were seen, one lasting for more than 24 hours. A few huge linear deposits of frass were found that must have been caused by intense synchronised defaecation by larvae in a column. Individual larvae measured during the study varied between 3 and 11 mm in length. From 20 July – 4 August, mean larval length increased from 6.3 to 8.4 mm and mean mass from 3.7 to 5.9 mg, although on any day there were large variations in both quantities between columns and between larvae. Possible reasons for column formation by these larvae are considered.

Introduction

At the end of July 2004, immense numbers of larvae of *Sciara militaris* Nowicki were found moving in closely-packed columns on a path in coniferous woodland at Barcaldine, near Oban, Scotland. These were believed to be the first occurrences in the British Isles both of this fly species and of the so-called "armyworm" phenomenon (Craik et al, 2005a, b). In July 2005, Jane Eaton and Tom Webster again found armyworms on the same path, 40 metres from the 2004 site. This had echoes of a similar finding 92 years earlier in Fayetteville, Arkansas, USA, where marching larval columns of *Sciara congregata* appeared at a particular site on 6 July 1912 and again on 16 July 1913 (Becker 1914). In 2005, columns were present almost daily at Barcaldine from 19 July to 6 August, providing better opportunities for study than in 2004. Here we describe some of our observations; more details, mainly biometrics, will be published elsewhere.

Observations in 2005

As in 2004, the columns were all on or alongside a five-metre-wide path running north-east to south-west through a Sitka spruce plantation. Despite daily searches, no columns were found more than three metres away from the path except for one column at seven metres. All were found along a 40-metre stretch of the path and most were on a 16-metre section of this stretch where the gap between the trees was greatest and daylight was stronger. Thus green vegetation was richer (see Craik et al 2005b for a list of plant species) and conifer needles were less abundant, forming a sparse layer on the bare, compact soil of the trodden path itself. By contrast, few or no green plants grew more than about three metres off the path where the needles formed a dense layer many cm deep on soft spongy soil.

No columns were seen on 2 August, but otherwise columns were found on every day from 19 July to 6 August, their numbers varying between 22 on 23 July and two on 6 August. Altogether, 203 columns were observed and 195 of these were measured: 137 columns (70%) were up to 100 cm long; 35 (18%) were 101-200 cm; 16 (8%) were 201-300 cm; and seven (4%) were 301-400 cm. The longest column (398 cm) occurred on 27 July and the shortest (6 cm) on 30 July. Columns often varied considerably in width along their length. Many tapered strongly towards the rear, often ending in a chain of single larvae touching head to tail. Similarly, the height (due to larvae being stacked vertically) varied considerably along a column.

The extraordinary spectacle of huge numbers of small larvae on the move sometimes led us and other onlookers to speculate that there must have been "millions". We estimated the actual numbers in each of four columns as follows. A small part of each column was collected, taken to a laboratory, weighed to the nearest milligram and counted. At the site, most or all of the column was weighed to the nearest gram and replaced on the ground (the larvae then usually re-organised themselves into a column within 30 minutes). The number in the whole column was obtained by proportion. In this way, a 200cm column was estimated to contain 13,320-19,980 larvae. Another column of *c.*50cm held *c.*4,920 larvae. A strongly tapering column comprising a body 65cm long and a thinner tail of 40cm contained *c.*8,000 larvae. A large column 218cm long, including a branch of 34cm, and of fairly uniform thickness held *c.*25,900 larvae.

Allowing for variations in thickness, it was concluded that the largest columns seen were unlikely to have contained more than 40,000 larvae. Moreover, most columns were short (<100cm) and usually thin. Allowing an average of 6,000 – 12,000 per metre, the total in the 22 columns on 23 July (1,830 cm in total, the most seen at any one time) was likely to have been in the range of 110,000- 220,000 larvae. Our initial reaction of "millions" was an enthusiastic overestimate.

The speed of forward movement of a column front relative to the ground was 1.8 cm/min (average of five columns). However, larvae on the upper surface of a column were moving at 6 to 8cm/min relative to the ground (averages of seven measurements on two columns). Thus, larvae riding on the back of a column travelled three or four times faster than the column front.

The path was almost level along its length, but sloped at about 10 degrees across its width. Of 125 records, columns were moving downslope on 69 occasions (55%), upslope on 29 (23%) and level on 27 (22%). Thus more than twice as many columns were found moving downslope as moving upslope, possibly because movement was partly gravity-driven in the direction of least resistance. Columns moved without difficulty up or down steep (70-80°) slopes for distances of several tens of centimetres, for example into or out of a drainage ditch that ran along one side of the path. Columns were markedly more numerous during the middle to late morning (09.00-13.00 hours) than later in the day or at nightfall, although no observations were made later at night or around dawn. Although the lifetimes of individual columns were not recorded, we gained the impression that they usually lasted a few hours at most (except for the ring described below). Columns were often seen coming out of the ground, disappearing into holes, or dispersing as larvae sank into the litter layer or soil. Columns were always in a state of change, sometimes varying in width or length from minute to minute, and commonly forking at the front or forming temporary side-branches. Some columns were seen to meet and unite, others to split into two by a fork or side-branch breaking off or by a break in the main trunk. Once an "X" formed when two columns touched laterally.

On two occasions we found unbroken rings of marching larvae. One of these was approximately circular with diameter of only about 4cm and, 35 minutes after it was first seen, it had degenerated into a chaotic mass that soon dispersed. Much more striking was a large ring, diameter 48-54cm, containing several thousand circling larvae. This was discovered at 09.55 hours on 27 July and the larvae were still circling when we left at noon. At 09.30 next day, the larvae were still in a ring, diameter 40-66cm, its centre shifted by about 90 cm from the previous day. The larvae, presumably the same ones, were still circling, but noticeably more slowly, and by 11.30 they had all dispersed and disappeared into the litter layer and vegetation. Thus the marching ring appears to have persisted for over 24 hours.

Through a magnifying glass, the movement of the massed larvae was mesmerisingly beautiful. They seemed to swim gracefully on and in a stream made

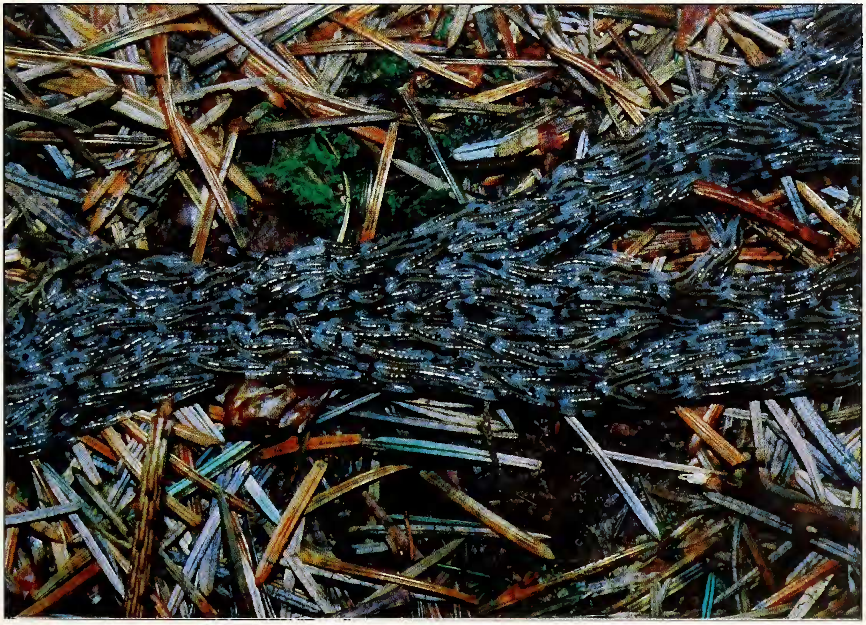

Plate F. Streamlined appearance of column of larvae.

up entirely of their own kind. They gave the impression of a continuous liquid flow, yet no free liquid was visible. Individuals moved forward by repeated longitudinal contraction and lengthening, each remaining in a straight line, and the many parallel bodies gave a streamlined appearance to the column (**Plate F**). The rhythm seemed not to be synchronised between larvae and there was no suggestion of writhing or of transverse waves along the larval body. Larvae at the front of a column behaved differently, constantly questing by pointing their heads left to right and up and down. This streamlined, apparently steady and purposeful movement occurred when the larvae were on dry leaf (needle) litter or dry compact soil. However, some substrates provoked a very different behaviour. Arriving at a patch of wet mud, those at the front sometimes stopped moving forward and a "pile-up" occurred. The column lost its streamlining and appeared as a chaotic mass (**Plate G**). Larvae moved in all directions until a new purpose was established and the column reformed and moved on, sometimes over the mud, sometimes over leaf litter. In similar fashion, columns encountered and circumvented fir-cones, stones and other obstacles (**Plate H**). Columns usually refused to move onto dry paper or onto a finger. Weighing of all or part of a column became possible when it was found that the larvae moved more readily onto moist paper.

Close-up photographs of larvae showed that the intestinal tract was often full of dark-coloured food remains. These appeared to be surrounded by clear yellow-brown liquid, possibly digestive fluid (**Plate I**). At other times, only a few dark flocculent food remains were visible suspended in the fluid, and occasionally no food remains were visible and the yellow-brown liquid seemed to fill much of the body. The larvae were moist to the touch, but no visible fluid or slime remained on the fingers and usually the columns left little or no visible residue on the ground. Once or twice the vegetation became discoloured by a buff or yellowish stain. Much more strikingly, huge quantities of black frass (faeces) were found on four occasions. One of these frass trails was 70 cm long (**Plate J**). Both the yellow deposit and the frass were on short stretches of trail along otherwise clean routes, implying that occasional short but intense bouts of synchronised defaecation had occurred. Although the defaecation itself was not seen, the deposits suggested a similarly brief and intense episode of feeding that caused rapid turnover of gut contents, possibly after an abundant food source had been encountered by the moving column.

The longest individual larvae were 11mm and the shortest were 3mm. The mean length of larvae, combined from several columns each day, increased from 6.3mm on 20 July to 8.4mm on 4 August. Likewise, mean mass increased from 3.7mg on 21 July to 5.9mg on 4 August. These increases show that larvae were growing for most of the time when columns were present, implying that they were feeding. However, there were large differences in the sizes of the larvae on any particular day, both within and particularly between columns. There was also great variation in thickness of larvae of the same length, some being very fat, others thin. This may have been sexual, as freshly emerged egg-bearing females are larger and fatter than males.

Although the larvae in the columns were exposed and apparently vulnerable, no predators were seen to approach them. However, few birds occur near the ground in these dense plantations of alien conifers. We saw only two birds during at least 50 hours of observation, a juvenile robin on 9 August and a female blackbird on 10 August – both of them after the columns had ceased to appear.

Temperatures on the ground surface, measured close to the columns, varied between 11.1°C and 13.5°C. Relative humidity on the ground was usually in the range 91-95%, but it was 80-89% on 29-31 July after 10-12 days without rain, and 97-98% on 3 and 4 August after heavy rain.

Throughout the period when columns were present, small flies were seen apparently following and occasionally settling beside the moving larvae. Some were caught and have still to be identified, although they are not thought to be sciarids. Larvae reared in captivity emerged between 14 and 18 August, so adults would have been expected in the wild at about that time. Sweeping with a net was carried out between 10 and 20 August over the full area where columns had appeared. Although a few adult Diptera and hymenopterous parasitoids were caught (still to be identified), not a single adult *Sciara* was encountered. An MV moth trap was run at the site for one night during this period, but it too failed to catch any *Sciara*. These failures are perhaps explained by the remarkable reluctance of the adults to fly; indeed, many or most of those reared in captivity never flew, some of them mating before dying without ever taking to the wing. If adults in the wild are similarly reluctant to fly, it might explain why larvae were found in almost exactly the same place in both 2004 and 2005.

Captive rearing in 2005

Larvae collected on 22 and 27 July were reared in spruce needle mould collected at the site as described previously (Craik et al, 2004b). Pupation of the two batches occurred on 5 and 10 August and most flies emerged on 14-15 and 17-18 August. As before, some larvae died around the time of pupation and, when fungal growth appeared, pupae were cleaned of mycelia and placed in clean boxes on moist tissue paper, the second batch also with clean needle mould.

When a box containing recently-emerged flies was opened, the jarring movement sometimes caused one or two to fly and escape, but most remained settled. Provided the tissue paper in the box was kept slightly moist, adults of both sexes showed no tendency to fly even when the lid was off, so that their behaviour could be observed. They were easily made to crawl onto pieces of moss or bark without taking flight.

Among those that emerged, females outnumbered males by about 10:1. Sometimes, both sexes were seen to flick their wings as though about to take flight. This may have been a form of sexual signalling, although neither sex was seen to respond to nearby wing-flicking. Sometimes a male was seen to mate with several gravid females in rapid succession, each mating lasting 5-20 seconds. Emergence of the second batch provided a much greater number of flies than the first. Gravid females, along with a smaller number of males, spent most of 17 August crawling over and into the small heap of moist needle litter. Many females deposited eggs (presumably after mating, although it was not established that mating always

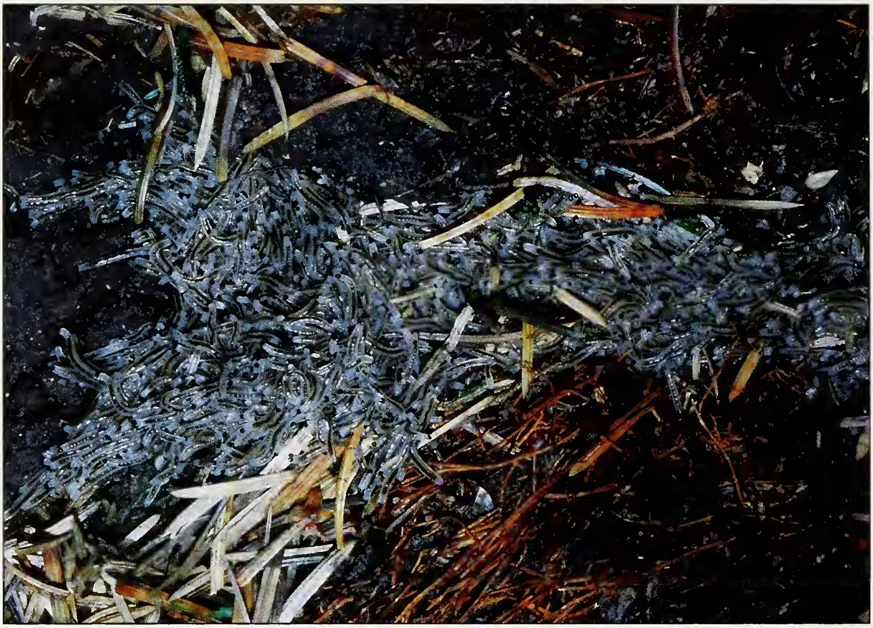

Plate G. Front of column that has encountered a patch of wet mud (left), showing change in behaviour of larvae.

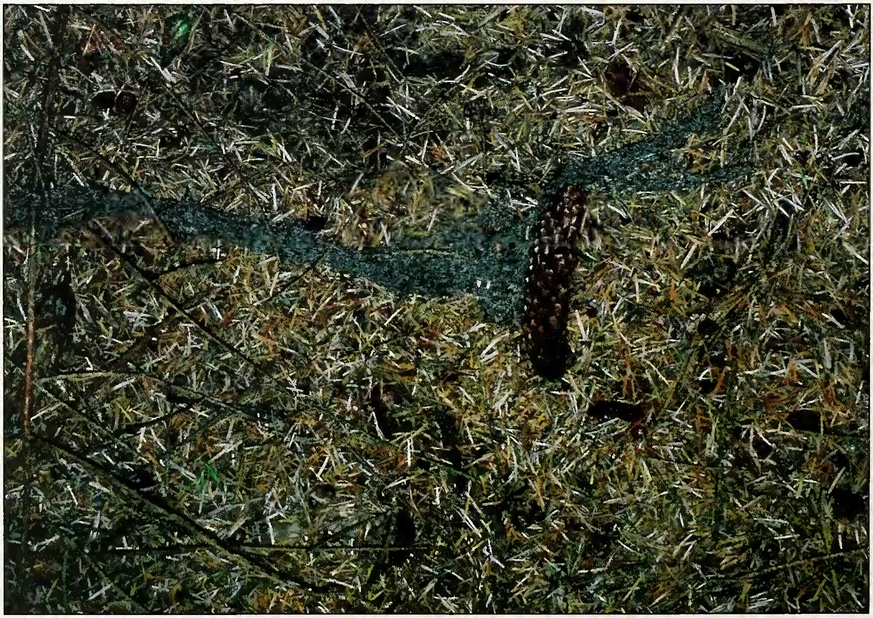

Plate H. Column of larvae that has encountered and gone around a spruce cone.

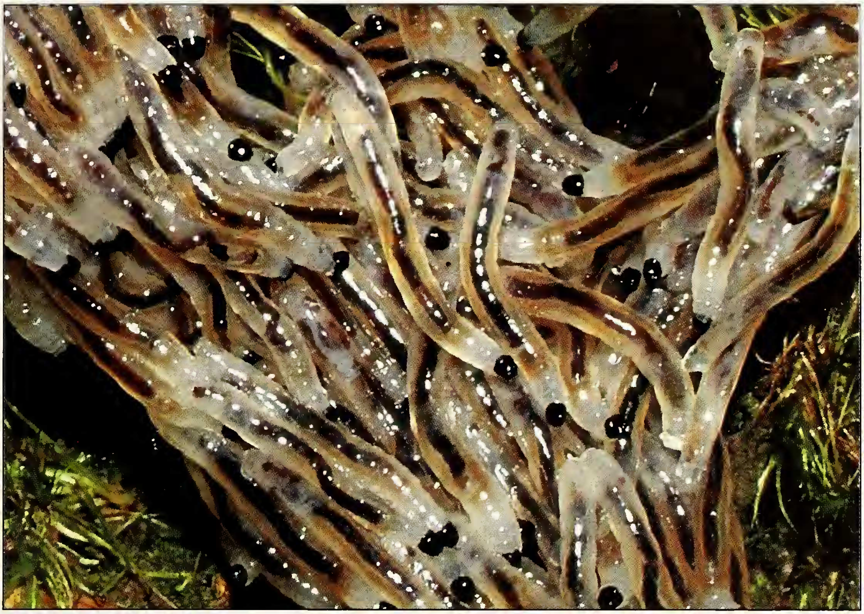

Plate I. Close-up of larvae showing dark contents of intestinal tract surrounded by yellow fluid.

Plate J. Part of a 70 cm trail of frass (pencil 17cm).

preceded egg-laying). On 18 August, many spent females and several males were dead or dying, scattered over the moist tissue. A few more gravid females emerged on 19 August. Thirty voucher specimens, including both sexes, along with some batches of eggs were preserved. All four stages of the life cycle have now been retained in PW's collection. Six adults, including both sexes, are with the Royal Scottish Museum, Edinburgh.

Discussion

Some possible reasons for column formation by sciarid larvae were considered by Menzel & Mohrig (2000). These included the search for food or a suitable feeding-place, the search for a site for pupation, the avoidance of desiccation, and the quest for *Lebensraum* resulting from the growth of large numbers of larvae in a small space. None of our observations provides a conclusive explanation of this remarkable behaviour, but some of them point to a possible connection with food and feeding. The increases in body mass and length show that the larvae must have been feeding throughout the period when columns occurred, although it is not clear whether feeding took place when larvae were hidden in the leaf litter or when they were moving as columns. Each column behaves much as if it is a single super-organism and one may speculate that it is a means of mass nutrition, picking up and distributing food along its length. Possibly this food is particulate, possibly some is digested by external secretions and dissolved into a thin film of nutritious liquid that both feeds larvae throughout the column and lubricates their movement. This might explain why the gut contained clear brown fluid at some times and solid food at others, and also why the moving larvae adhered so closely to the column. Moreover, the massive linear deposits of frass seem to imply that brief but intense feeding occurred whilst the columns were moving. Finally, most columns were on that part of the path where sunlight was strongest and un-decomposed vegetable food would have been most abundant.

Whatever the explanation, we were drawn back every day not just to study, but simply to watch an amazing spectacle. We hope that others will look out for larval columns elsewhere in the British Isles, particularly in late July and early August, as it seems unlikely that they should be confined to this one site. The movement of the larvae is not obvious and, on first sight, columns can be mistaken for discarded plastic waste or the cast skins of snakes.

References

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